

A
DISCOURSE
CONCERNING
TIME,

With Application of
The *Natural Day, Lunar Month, and*
Solar Year, as Natural,

And of such as are derived from them:

As *Artificial Parts of TIME, for*
Measures in Civil and Common Use

For the better understanding of

The *Julian Year and Calendar*

The *First Column* also in our *Church-*
Calendar Explained,

With other *Incidental Remarks.*

The Third Edition.

By WILLIAM HOLDER, D.D.

Canon Residentiary of S. Paul's, London;
and Fellow of the Royal Society.

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T H E
P R E F A C E.

THE Reader is not to expect here an Elaborate, Methodical, or Just Treatise for the Entertainment of the Learned; but will find a Collection of several Memoirs, such as may be all of considerable use to those who are not Proficients in this kind of Knowledge.

The Author, having casually discoursed on the ensuing Heads, to one or two Ingenious young Gentlemen; and for their better Comprehension, and Remembrance, put many of them dispersedly in Writing: He has now revised those Papers, and enlarged them; Digressing sometimes, and taking in some Astronomical, Chronological, and other Remarks, very worthy and equally needful to be known, though not so directly pertinent, or necessary to the Explication of the

THE PREFACE.

Julian Year, and Ecclesiastick Calendar; which was his chief Intention, but yet giving some light unto them.

He hath since been prevailed with to let them be published, as being thought profitable for the use of younger Students, whereby to possess them with some useful Notions; such as may prepare and induce them, with more Pleasure and Ease, to advance into the Study of deeper and larger Contemplations of this kind.

And for the use also of such as have not considered these things, but are content (for want of easie Introduction) to be ignorant, and careless, of this so necessary Knowledge (of whom there are too many to be found, the more the pity:) That they (if they please) may see the Grounds of our Calendar, and Measures of Time; and know the Reason of the Differences between the Reformed Calendar, and our old Julian, in respect of Accounts of the Progress of the whole Year, and of the Moveable Feasts, &c.

'Tis hoped also, This plain Discourse may be useful to many of our Clergy, whom it concerns to have some knowledge of these Matters.

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DISCOURSE
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TIME, &c.

C H A P. I,

Of Measure in General. § More particularly of Time ; and Difficulties concerning it.

GOD made all things in Number, Weight, and Measure ; and gave them to be considered by us according to these Properties, which are inherent in Created Beings. But without an Act of the Rational Soul,

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comparing these in their several kinds, one to another; they would be as nothing. And therefore the ancient Greeks very fitly termed the Habitude of any one of these to another of the same kind, λόγος, the *Ratio* of it; because it is our Rational Notion of their Equality, or Difference, when we apply one Number, or Weight, or Measure to another of the same kind, and consider, and compute, what Proportion one bears to the other.

It cannot be expressed, what universal and necessary Use there is of the Consideration of Number, Weight, and Measure, in common Life. Not to speak of Order, and Beauty, which consist of Symmetry; nor of building Houses and Ships; all humane Society is upheld and managed by the Use of these. No Commerce, or Exchange, or Trade, can be without them; and consequently, no Benefit of Society.

And therefore, the Sagacity of Learned Men has advanced Arts and Sciences, for the better knowledge and use of them. For Number, Arithmetick; for Weight, Staticks; and for Measure, Geometry.

metry. And for finding out the Original Measures of Time (of which I shall have occasion to speak) Astronomy. All Magnitudes are capable of being measured ; but it is the application of one to another, which makes actual Measures ; and Things actually measured.

Measures ought to be stated and known before they be applied to measure other Quantities. A Measure therefore has reference to something that is or may be measured by it, with application of the Mind. Any given Length of a known Line, under a certain Denomination, may serve to measure out any other Length, be it Equal or Unequal. A Concave Measure, of known and denominated Capacity, serves to measure the Capaciousness of any other Vessel ! In like manner, To a given Weight, the Weight of all other Bodies may be reduced ; and so found out. And Number, in its way, measures them all.

We may measure any Quantity, by any other known Measure of the same kind. But Measures that are most fitting to be applied in this manner for common Use, ought to be taken from

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some certain quantity universally known; so that every one may have some Idea of that Measure, though perhaps not perfect.

If we would measure any Length, Breadth, Depth, Height, or Distance; by a Line, Real, or Imaginary, between the two extreme Terms, *A quo*, and *Ad quem*: we must apply some known Measure, wherewith to meet it.

For such a known Measure, the Ancients had recourse to some Original Patterns in Nature, sufficiently known; As, chiefly, to the Stature of Humane Body; and, for Variety of Measures, to Parts of it, reconciling them one to another, by assigning agreeable Proportions of the Whole to its Parts, somewhat near Truth to make them Originals, for Authentick and Useful Measures. The Parts were especially, The Arm, Hand, and Foot. The Arms, spread cross in a streight Line, and measured from the end of the long Finger on one Hand, to that of the other, made a Measure equal to the Stature, and is named a Fathom. Half of that, *that is*, from the

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the End of the long Finger of either Arm, so spread, to the middle of the Breast is, with us, called a Yard. From the Tip of the Elbow, to the End of the long Finger, is half a Yard, and a quarter of the Stature, and makes a Cubit; the first Measure we read of, the Ark of *Noah* being framed and measured by Cubits. A Foot (the Length of it) is a sixth Part of the Stature, and a Measure much used. A Span, $\frac{1}{3}$ of it. A Palm, or Hand's breadth, $\frac{1}{24}$: A Thumb's breadth, or Inch, $\frac{1}{72}$: A Fore-finger's breadth, $\frac{1}{96}$: And other such Measures. Now, tho' all these may not be found exactly in those Proportions; yet, to suppose them such, makes them fit Patterns of Measure, being made Commensurate: The less being *aliquot* Parts, or composed of *aliquot* Parts, of the greater.

Then, measuring Land, by walking over it, they styled a double Step (*i. e.*) the Space from the Elevation of one Foot, to the same Foot set down again, mediated by a Step of the other Foot; a Pace, equal to 5 Foot; a Thousand of which Paces made a Mile, which is
a Mea-

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a Measure serving for any Distance on Earth, and even for the Height of the Spheres.

Likewise for small Measures, they considered a Barley corn; the Breadth of it $\frac{1}{3}$ of an Inch, and the Length $\frac{1}{3}$: And less than that, the Breadth of an Horse's-hair taken from the Mane, 48 whereof set in Breadth, are supposed to make an Inch.

These are Originals; from these our Measures of Length are taken: but I cannot call them Standards; for Standard-measures must be Certain and Fixed; and are made by Consent and Authority of every Nation for it self, and the People in it. For though the Measures before spoken of be known to all, and give a gross Conception of all Measures derived from the Natural Inch, Foot, Cubit, &c. yet they cannot be so exactly stated, but you must imagine a great Inequality, if every Man should measure from his own Thumb, Foot, or Cubit. And therefore several Nations (though intending to follow a mean) happen to pitch upon several Sizes of these parts of Man; and consequently,
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though they keep the same Denominations and respective Proportions of these Measures; yet the Inch, and Foot, and Cubit of several Nations, become to be somewhat different from each other: As, *ex. gr.* The English Foot is somewhat shorter than the Parisian, and longer than the Roman Foot.

And therefore the Consent, and Government of each Nation Enact by Authority of Laws, what shall be accounted the Measure of a Foot, and of the rest proportionably; and make Authentick Models of those Measures to be publickly kept, and be the Standard of all private Measures of the same kind, and by which every Man under that Government is to guide himself.

And thus it is in Weights. They began at a known Body, a Barley-corn, the Weight whereof is therefore called a Grain; which ariseth, being multiplied, to Scruples, Drachms, Ounces, Pounds, &c. and then those Weights, (as they happen to take them) are fixed by Authority, and Exemplars of them publickly kept.

And

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And it is the like in Concave Measures. The capacity of the Shell of a middling Hen's-egg, may be the Original from whence Pint, Quart, Gallon, &c. are made Patterns for all capacious Measures; and their Authentick Fabricks stored in Publick for every one to make his Measures by, and by which to have them examined.

Now although (in these Instances) a Hair, and Barley-corn, and humane Body, and a Hen's-egg, be truly Original and Radical Measures, universally known; and so give us a gross Idea of those other stated Measures derived from them; yet these cannot be styled Standard-measures, because they are not universally fixed, but are unequal amongst themselves, and unequally taken by several Nations. But Standard-measures are National, taken from those Originals (with such Diversities as shall happen) and constituted, as every Government shall think fit to ordain, and make known unto their Subjects. The Original-measures are found in Nature, not accurately fixed, but subject to some Variety: The Standard-measures taken
from

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from them with some Analogy to them, are firmly settled by Consent and by Authority, with some Diversity in the several National Establishments.

This is premised, for the better clearing of that which is my more proper Subject, *The Measures of Time*. For which, because we do not find any Universally known, and Imitable Original here below on the Earth, because it is of a different and more subtil Nature, than those other aforesaid Measures; we must therefore seek above, and have recourse to the Motions of the Celestial Bodies; reckoning our Time by numbring the successive Parts of those Motions; and herein, if we will be accurate, we may take the most Equal Motion, by which to measure; viz. That of the *Primum Mobile*. But that being difficult to measure, we do, and may best take our Measures for common Use from those Heavenly Bodies, which carry Light along with them, to guide us in the Observation of their Motions. And those are (most eminently) the two great Luminaries, the Sun, and the Moon. The Diurnal, and Annual Re-

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volutions of the Sun, which to us are the Measures of Day, and Year ; and the Synodic Revolution of the Moon, by which the Month is measured. These Motions are, to us, the original and radical Measures of Time. And the Day, Month, and Year, measured by them, and best known to us are used as Standard-measures ; as likewise others Arbitrarily, and Artificially deduced from them, by Partition, or Collection, and being reducible to them : as Minute, Hour, Week, Month of Weeks, Solar-month, &c.

As if it be asked, How much is the Length, Breadth, Height, Depth, or Distance of any thing given ? I must answer, (not by the Original, but by the aforesaid known, denominated Standard-measure) so many Inches, Foot, Cubits, Fathoms, Furlongs, Miles, &c. as the Quantity proposed shall require. So if I be asked concerning Duration ; How long is the Age of a Man ? The common Answer must be (with the Psalmist) *Threescore Years and Ten* ; which are indeed measured by the Time, so long as the Sun is in making seventy Revolutions round the Ecliptic ; which Revo-

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Revolutions we, by Divine and humane Authority, call Years, as a Stated-measure of Time, by which we keep our Accounts. And in the same manner, less Durations are measured by Months, or Weeks, or Days: And if they be yet less, than by the Parts of a Day, *viz.* Hours, Minutes, &c.

The Celestial Motions numbred by an Act of the Mind, as the Parts of them succeed one another *secundum prius & posterius*, are the original Measures of Time; and by help of the Lights in the Firmament, are so perceptible, and easily known to us by the Interchanges of Light and Darknes, Succession of Seasons, and Termination of Revolutions and the manifest Effects of them: that from thence we have a more Familiar, Secondary-measure of Time, a kind of Standard-measure of all other Motions, or Rest, or Duration, alluding to those other Standard-measures spoken of before (but with some Differences which I shall touch upon.) And these are principally, the Day, the Lunar-month, and the Year.

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I do not intend to fall upon nice, Philosophical Disquisitions about the Nature of Time, and curious Questions relating to it: But upon the Use of it, *in Vitâ communi*; from the visible Secondary-measures thereof, agreed upon, and practised, according to both Divine and humane Institution.

If the Revolution of the *Primum Mobile* be (to the Curious) the first equal Standard measure of Time, and we may have such a Conception of it; yet I see not how we can so easily discern and usefully apply this Motion, as a Measure of Time; but remotely by the Guidance of the Lights in the Firmament. For the Light of those Bodies doth immediately discover to us the Succession of their own Motion; and mediately that of the *Primum Mobile*, whose Parts are numbred upon the Degrees of the *Equator*. Where we treat more generally of Time, the nearest and easiest way is, to be guided immediately by those Lights; and make the Day, and Month, and Year, our Measures of Time.

And as all other Measures of Time are reducible to these Three, so we labour
to

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to reduce these Three (though strictly of themselves incommensurate) to one another, for civil Use, measuring the greater by the less, *viz.* the Year by Months, and the Year and Month by Days, and Parts of Days: So that they may be indifferently used as one agreeable Measure of Time, greater or less, as there may be occasion to apply the Measure.

There is a great Difference, which renders the Account of the Measures of Time to be of much more difficult and curious Contemplation, than the other; because the other original Measures are to be found every where on Earth, and the Standards of them Arbitrary; whereas both Original, and what we may call Standard-measures of Time, are above in the Heavenly Spheres. And because the other Measures, before spoken of, are of continued Quantity, permanent and visible, and for the most Part tractable; whereas Time is always Transient, in a continual Flux, neither to be seen, nor felt, nor reserved; but only measured by an Act of the Mind, by Observation, and Application of those

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Moti-

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Moti-

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Motions which are the Measures of it : We cannot keep by us settled and permanent material Standards of the Measures of Time as we do of the other.

There is another Difference. That the Heavenly Motions, (though intricate) are more stated and certain, than the Terrestrial Models of the Measure of those other Quantities before discoursed of, and are indeed both Originals, and Standards. And, if we will also call the Day, and Year, Standard-measures, it is because they are unalterably constituted by those Motions, and are better known to us, whilst we follow that Light which goes along with those moving Bodies; and because they have some Stamp of Authority from the Almighty Lord of Heaven and Earth, and from Regulations of the Calendar by publick Authority in several Governments.

And though, from the former of these Differences, I conceive, we cannot so properly call the Celestial Motions, Standard-measures; because we cannot make any such standing Measures to be reserved, and kept for publick Use, and produced

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duced when we please, that they may be resorted unto, and applied to the Measures which are used; as is done in the material Standard-measures, and Weights; as Yard, Gallon, Pound, &c. yet from their Certainty (which is the other Difference) we may in some manner look upon them as a kind of Standard measures; because all Measures of Time are reduced to those we commonly use: But they are improperly called Standards, because (as was said) they cannot be made Standing-measures; for to be such does not comport with the Nature of Time.

I had rather called them *Stated* Measures; and we may conceive them to correspond with, and supply the use of those other kinds of Standard-measures: and having also some Stamp of Authority, by which they are settled, and stated, something also different from Nature.

For, as was said of Measures of Length, and of Capaciousness, and likewise of Weights: So here also, the Measures of Time, are (in their way) subjected more or less to civil Sanction. Thus in

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Rome (not to speak of other Nations) *Romulus*, and *Numa*, and after them, *Julius Cæsar*, Ordered, and Constituted the Account, and Computation of Years, and Months; which last Order we of *England* still follow, though in long Tract of Time, some Anomalies are crept in, which makes our Calendar vary from the true Account of Time.

There is one remarkable Instance of this, how we measure our Time by Law, and not by Nature, and that is the Solar Month; which though it be no Periodical Motion, and not easily Mensurable, and the Months unequal amongst themselves, and not to be measured by even Weeks, or Days; as naturally consisting, according to the mean Motion of the Sun, of 30 Days, 10 Hours, and near half an Hour: Yet by civil Sanction, and Constitution, this is made to us the chiefest Measure of the Year. And these Months are measured by Integer Days, though unequally; some by 31 Days, some by 30, and one by 28, and every fourth Year, by 29. This Solar-month, I say, is by civil Sanction and Authority, notified in Authentick Calendars,
made

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made for our Use the chief Measure of the Year: a kind of Standard, by which we measure out our Time. But these Months do not so much come under my Consideration; but more properly, in order to Ecclesiastical Computations, the Lunar-month; which is Natural, and Periodical, and by which Moveable Festivals of the Christian Church are regulated.

We read in *Moses*, *That God created Lights in the Firmament of Heaven, to divide the Day from the Night, and appointed them for Signs, and for Seasons, and for Days, and for Years*, Gen. 1. 14.

The visible Motions of all the other Lights of Heaven might afford us several Measures of Time, if we could number them. But because most of those Motions are not so evident to us, and the great Lights are sufficient, and serve also to measure even the Motions of those other; we therefore, following the Guidance and declared Design of the Almighty Providence, deduce our Measures of Time from the successive Motions of the Sun and Moon, and most from the Sun: Both of them having Sig-

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nal Motions, and giving sensibly Apparent Signs; the Sun of Seasons, and of Light and Darknes, *i. e.* of Years, and of Days; The Moon of her changeable Habitues to the Sun, and consequently of her Phases, or different Appearances to us, and of her Seasons. For she makes also four quarterly Seasons within her little Year, or Month of Consecution. I need not add, how generally, and how much those quarterly Seasons of the Moon are observed.

C H A P. II.

Of the Sun's Motion; Measuring Days, and Years: and making them our Ordinary Measures of Time. § Difficulties of Accounting by them. § The Inequality of the Sun's Motion, and of Solar Days briefly mentioned. § From Day and Year other Measures derived. § And their Usefulness. § The Division of a Circle into 360 Degrees,

WHether the Sun actually moves out of his place, or else is fixed upon his own Center, and only seems
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to move, and the Motions be attributed to the Earth, after the *Copernican* way; which of late is more generally favoured, because it does much better, and more easily solve all the *Phænomena*: Yet it is still the Sun, which (according to the Scripture) by his Light governs the Day, and by his Light and Heat makes the Seasons of the Year; and terminates to us, and discovers unto us the Revolutions of the Earth, (supposing the Motion thereof) both in it self, and also about the Sun. And it is all one, as to our Sight, and Calculation of Time, whether the Motion be attributed to the Earth, or to the Sun: As the Distance is still the same, whether we fanſie the Shore to recede from the Ship, or the Ship to move from the Shore.

I ſhall therefore in this Discourse, (because of Prepoſſeſſion of the one, and Prejudice againſt the other) ſuppoſe the Sun to move according to the *Ptolemaic* System.

First then, from the Motions of the Sun, as original Measures, are conſtituted for our Uſe, Two moſt Signal, Unverſal, Natural, Diſtinct, Perceptible

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Measures of Time; which are as Standards for us Mortals to measure our Time by: And these are, the Day, and the Year.

The Day, *i. e.* the Natural Day, *Nux̄d̄īm̄ēc̄v*, though it be accounted in General to be measured by one whole Revolution of the *Primum Mobile*, and with it of the Equator upon the *Axis* of the World: Yet more precisely, and truly, it is measured by the Revolution of the Sun, carried along with the Motion of the *Primum Mobile*, upon the same *Axis*, either in the Equator, or in less Circles, very near Parallel to the Equator, which are therefore called *Parallels*.

For the Day, being visibly governed by the Sun, is a little longer than the Revolution of the Equator: so much, as is occasioned by the Advance of the Sun in his Annual contrary Motion along the *Ecliptic*, in that Space of Time; which is about one Degree of the *Ecliptic*, and which the Sun passeth in about four Minutes of an Hour.

I say, the Solar-day, from the Meridian of a Place on Earth, round to the
same

same Meridian again, is a little longer than the same Revolution of the Equator: *viz.* so much longer, as the same Point of the Equator is returned sooner to the same Meridian, than is the Sun; which in that Space of Time, by his Annual contrary Motion Eastward, will be advanced near a Degree of the Ecliptic, cross to the Motion of the Equator.

As, suppose the Sun to be in the first Point of *Aries*, *i. e.* in the Equinoctial; then, by what Time the first Point of *Aries* will be carried round with the Diurnal Motion of the World contrary to the Order of Signs, from one Meridian to the same again: In that Time the Sun will be advanced, as was said before, near one Degree of *Aries*, contrary to the other Motion; and so will be found distant from the said first Point, about a Degree, and will require about four Minutes of an Hour, to be brought back by the Motion of the *Primum Mobile*, to the same Meridian: *i. e.* The first Point will return to the Meridian sooner by about four Minutes of an Hour, than the first Degree of *Aries*, where about the Sun will be found at that Time. And so much

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much the Sun's Diurnal Motion is longer than the Revolution of the Equator.

As a natural Day is measured by the Revolution of the Sun, from any one Meridian to the same Meridian again ; So a Year is measured by the Motion of the Sun round the Ecliptic, upon the *Axis* of the same, from one Point of the Ecliptick (suppose from the first Point of *Aries*) to the same Point again : And this Revolution is performed Obliquely, and contrary to the other ; so that the Day and Year seem not to correspond with, or regard each other.

The Year is measured to us by the Revolution of the Sun in the Ecliptic ; The Day by his Motion in, or Parallel with the Equator ; The Year by the Sun's Motion Eastward *in Consequentia*, or *secundum Seriem Signorum* ; The Day by his Motion Westward *in Antecedentia*, or, *contra Seriem Signorum*.

The Day is no *aliquot* Part of the Year (strictly speaking) neither to Compound, or Divide the Year, so much as by Units. If the Year comprehend Days, it is but as any greater Space of Time
may

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may be said to comprehend a Less, tho' the less Space be incommensurate to the Greater.

And from these differing Properties of Day and Year, arise Difficulties in carrying on and reconciling the Supputations of Time, especially in long Measures. Although it must be confessed, that for vulgar Use, where is no need of, or regard to exact Calculation; we have no better Measure of a single Year, than the Day, and the Artificial Solar-month, consisting of even Days: Because the Succession of Days is so visible, and so easily numbred, that by these we may keep as good an Account of the Year, as is needful to our common Occasions.

But if we thus measure many Ages of Years by even Days, our Computation will be perplexed.

For the Year (without regard to Days) ends, and is terminated with an odd Day, and odd Hours, and odd Minutes, and odd second Minutes; if we go no farther: So that it cannot be measured by any even Number of Days, or Hours, or Minutes.

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The Circle of Degrees in the Ecliptic, which make a Year, are 360 ; the Circle of Days within a Year is broken into 365, and almost a Quarter. The Sun is carried round the World backward (the daily Motion compared with the Annual) 365 Times, and almost a Quarter, while he makes his own Round forwards of 360 Degrees of the Ecliptic : So no Circle of even Days can make a Year ; which (as was said) creates difficulty in keeping account of Years.

And the very Steps which the Sun appears to us to make through the Ecliptic, are unequal ; as also the Days, if one be compared to another successively throughout the Year, are found not to be equal, and will not justly correspond with any Artificial, or Mechanick equal Measures of Time ; as by Watch, Clock, &c.

So that we are to find out the Extremities on both Sides, and from and between them, the Middle daily Motions of the Sun along the Ecliptic ; and to frame Tables of Equation of Natural Days to be applied to the mean Motion, by Addition, or Subtraction, as the
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the Case shall require: which are styled *Prosthaphereses*; The Greek word *ωσφαιρεσις* being fitted to comprehend both Addition and Subtraction.

The Day is limited to us by the Interchanges of Light and Darkness; and the Year by the successive Seasons of Winter, Spring, Summer, and Autumn: And these are Signal and Certain (tho' not Original) Measures of Time, constituted by the Revolutions, and manifested to us by the Light of the Sun. And we have no other Measure, (save one of the Moon) but are, as we say, Artificially made out of these by compounding or dividing them. No other Measure of Time deduced from any other Original than the Motion of the Sun, can be so evident to us: For these are apparent, at least after a gross manner, to all Mankind, and to almost all living Creatures; others only to the Learned in Astronomy, or else derived from these by Institution for civil Use.

And from these *Constituted* Measures, and Denominations of Time, viz. Day, and Year, (not excluding the Lunar-month) all other Measures of *Duration*,

or

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or *Successive Motion*, are Artificially contrived for civil Use; by dividing *these* into less Parts, or collecting and compounding them. The Day for small Measures, chiefly by Partition, and the Year for Great, by Collection of Numbers of Years: Or we may measure by Numbers of Days, and Parts of a Year.

Some divided the natural Day, comprising Day and Night into four Parts, or Quarters for the Day, and four for the Night; and each of these Quarters consisted of three Planetary Hours: The Artificial Day from Sun-rise to Sun-set (be it longer or shorter) being divided into 12 equal Hours; and the Night likewise into 12: Three of which Hours made one Part, or Quarter. But the Hours of the Day were always unequal to the Hours of the Night, according to the Increase, or Decrease of the Length of Days and Nights: Only if the Sun were in the Equinoctial, or the Inhabitants under the same; then the Days and Nights being equal, so would the Hours be also.

But

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But the general Usage is to divide the whole natural Day into 24 equal Hours, an Hour into 60' (Minutes) a Minute into 60" (second Minutes) a second Minute into 60''' (Thirds) and so on.

And by thus dividing the Day, we compute the smallest Measures of Time: and by compounding Years, we measure the greater Spaces of Duration.

But we must observe, that the Day is not thus divided by Nature, as it is into Light, and Darknes; and by the Meridian into Noon, and Midnight: But this Division (as most others are) is Artificial, and at our pleasure, by Consent of Nations.

We may observe likewise, that the common Division of a Circle, into 360 Degrees, or Parts, is also Artificial, and Arbitrary: But it is well chosen and pitched upon, as being a Number that abounds with Integer *aliquot* Parts, and therefore most apt for Partition; and being, as near as may be, suited to the Number of Days, which the Sun makes in a Year, in compassing his whole Circle of the Ecliptic; viz. 360, to 365,
And

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And in both respects it is best fitted for Astronomical Uses.

Of the former of these, the *Aliquot* Parts of the Numbers 360, take a short View, as follows;

1 ——— 360	8 ——— 45
2 ——— 180	9 ——— 40
3 ——— 120	10 ——— 36
4 ——— 90	12 ——— 30
5 ——— 72	15 ——— 24
6 ——— 60	18 ——— 20

In toto 23 several *Aliquot* Parts.

The Number 6, is celebrated for having all *Aliquot* Parts; *viz.* 3, 2, and 1; and for being composed of the Aggregate of them all; and therefore is stiled, The Perfect Number.

And 10 is the first of the Saracenical Characters, or Figures with Cypher, that great Friend to Calculation; or rather, which changeth Calculation, strictly so called, into easie Computation. Now the Number 360 consists of the Square of 6, *viz.* 36, multiplied by 10, or having a Cypher added to it.

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Of these 360 Degrees, or Parts of a Circle, every one may be supposed to be subdivided into Minutes, Seconds, Thirds, &c. And these Parts are marked alike with the Parts of an Hour, *ex. gr.* For Hours; 3^H , 2^I , 5^{II} , 4^{III} , and so onwards: For Degrees; 3^{Gr} , or 3° , $2'$, $5''$, $4'''$, &c. *i. e.* 3 Hours, or 3 Degrees, 2 Minutes, 5 Seconds, 4 Thirds, and so forwards: A Minute being $\frac{1}{60}$ of an Hour, or of a Degree; a Second, $\frac{1}{60}$ of a Minute; a Third, $\frac{1}{60}$ of a Second; &c. So that one Hour, or Degree, contains 60^I , 3600^{II} , 216000^{III} , and as many Fourths IIII , as is the last Number multiplied by 60; *viz.* 12960000^{IIII} ; almost 13 Millions.

By Composition, or Joint Number of Days, besides such as have been formerly in use, we have now chiefly, the Week, made of seven Days; and a Month, made of 4 Week, or 28 Days.

By Partition, or gross dividing of the Year, we have the 4 Quarters, or Seasons of the Year; we have 12 Calendar-months intended (however now unequally constituted at pleasure) to measure the Movement, or Passage of the Sun
C
through

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through every of the 12 Signs of the Zodiac.

○ Lastly, By compounding, or numbering Years, we keep Account of Ages, and publick Transactions, and memorable Accidents: we make Cycles, and Periods of Years, as Decads, Centuries, Chiliads, &c. chiefly for the Use of Computations in History, Chronology, Astronomy, &c. The Numbers of Years, by which we measure the Spaces of Time; having their several *Epocha's*, or Beginnings; as, from the Creation of the World; from the Flood; from the first Olympiad; from the Building of *Rome*; or from any remarkable Passage, or Accident, giving us a pleasant Prospect into the Histories of Antiquity, and of former Ages.

We Christians make the reputed Year of the Nativity of our Blessed Saviour our chief *Epocha*, from which to make our Dates, brought in use first by *Dionysius, Exiguus, Abbas*, who lived in *Justinian's* Reign, about the Year of our Lord 528: And tho' his Computation may perhaps differ two Years from Truth, as *Helvicus*; or more Years

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Years, as others are of opinion; yet since it is, and has been universally received over all Christendom, our Compute by it is, as for the Use of it, certain, and not liable to any Error or Mistake. It was stiled *Æra Dionysiana*, or, *Æra Christiana*, and afterwards *Vulgaris* was added to it, to distinguish it from *Æra Christiana Vera*, as contended for though never in use.

Till then, the Accounts in use were, the Olympiads, the Consuls, *Urbs Condita*, Indictions. The Olympiads were a small Cycle, but of four Years, still repeated, and numbering withal the Repetitions: But *Iphitus* made them an *Æra*, by accounting a continual Series of expanded Years from the first Olympick; and they were used both ways, but chiefly the Olympiads, by Quaternions.

C H A P. III.

Of Epocha's, Cycles, or Periods. § Of the Dionysian Period. § Of the Cycle of the Sun; and Changes of the Dominical Letter. Containing also an Account of the Week; and Bissextile. With a Table of the Dominical Letter, &c. § Some other Periods; particularly, that called the Julian. § The Indiction. § Some principal Æra's, and Periods; with a Table, reducing them to the Year of our Lord.

HERE, if I may have leave to digress, and take in Notions, tho' not so pertinent to our present Design; yet equally profitable and useful to young Students, for whom this Discourse is intended: I would in this Place say something more of *Epocha's*, and *Periods*.

And, first, I take *Epocha* to be the Head, or Beginning, (the Pause, *Ἐποχή*, or Stop, if you reckon up, or backwards as far as you can:) And *Æra*, the Continuation, or Series of any Account

count of Years; which is, or may be supposed to be extended, and numbered onwards, as long as Time shall have a Being.

Secondly, A Cycle, or Period, is an Account of Years that has a Beginning and an End too; And then begins again and again, as often as it ends; and so obtains a Perpetuity. The *Æra* has but one Beginning, which is the *Epocha*, if we speak strictly, though the Words are often promiscuously used: And from thence a continual Extension.

The Cycle, or Period, has its Continuation by beginning again as oft as it ends, going as it were in a Circle, and thence it has its Name. Thus the Cycle of the Moon, after every Space of 19 Years, begins again, *toties, quoties, in infinitum*. I think we do more commonly use these words so, as to stile a lesser Space a Cycle, and a greater by the Name of Period; and you may not improperly call the Beginning of a large Period, the *Epocha* thereof. For the Derivation of these Words, *Epocha* and *Æra*, I refer you to the Etymologists.

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The aforesaid *Dionysius* (or, as some affirm, *Victorius Aquitanus*, about 70 Years before him) considering that a small Cycle of Years (by reason of its often Revolution) cannot give so certain a Character of Time, as a large Period, contrived a Period, useful for Computation, consisting of 532 Years; by applying the Cycle of the Sun 28, to that of of Moon 19: which multiplied together, give the Number of 532; beginning as oft as those two Cycles take their Rise together at 1, as they did lately in the Year 1672. *Dionysius* however gave it a new Beginning, by applying it to the Year of our Lord; and therefore it was generally stiled, the *Dionysian* Period. This Period has had but 4 Beginnings since *Christ*; viz. *A. D.* 76, 608, 1140, 1672: and this present Year 1693 is the 22^d Year of this Period.

As the Cycle of the Moon serves to shew the Epacts, and that of the Sun the Dominical Letter, throughout all their Variations: So this *Dionysian* Period serves to shew these two Cycles both together, and how they proceed, and vary all along, till at last they accomplish

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plish their Period, and both together take their Beginning again after every 532^d Year.

And it serves farther also (which was the chief Design of it) for more certain Computation, by how much it is a larger and more comprehensive Period, and under a more undeceivable Calculation.

The two Cycles, which make this Period, are (or ought to be) very well known to all. One of them, that of the Moon, or golden Number, is at large explicated in the following Discourse: The other, that of the Sun, so called, because it shews the Sunday Letter, being a Table or Cycle of the Changes of the Dominical Letter; which I shall briefly here explain.

Instead of the ancient *Roman* division of the Month, into Nones, Ides, and Calends; we reckon the Days of the Month in Order: And instead of their accompting by their *Nundinae* (*quasi Novendinae*) their Mercates, or Fayrs, for the Country-People to come to Town every 9th Day, for Commerce and Trade; and to receive their Laws;

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(as the *Greeks* reckoned by Ten's, dividing their Month into 3 Parts) we, as the *Hebrews* number our Days by Weeks, and their Returns, after every 7 Days ; which the *Jews* did in relation to their Sabbath, (and possibly the *Affyrians*, &c. in relation to the Quarters of the Moon, consisting each of about 7 Days) and we, as Christians, for our Lord s-day.

We describe the Days of the Week by seven several Names, as Sunday, Monday, Tuesday, &c. And to distinguish them in the Calendar, there are 7 Letters appropriated, and set in Alphabetical-order before them, and so repeated throughout the whole Year ; viz. A, B, C, D, E, F, G ; and some one of these is the Dominical Letter, or the Letter for Sunday ; and the Letters following for the other Days, as they follow.

But the Sunday Letter is not constantly the same, but is changed once in every common Year, and in every Fourth, or Leap-year, twice. And the reason is, first, because the common Year does not consist of Just Weeks,
but

but of 52 Weeks, and one Day. So that as the Year begins with A, set before New-years day : So it ends with A, set before the last Day. And the Year beginning again at A, there will be two, A, A, falling together, *Dec.* 31. and *Jan.* 1. and if one of them, (the former) happen to be Sunday, the other in course must stand for Monday ; and then reckoning onward, Sunday must fall upon the first following G, and G will be the Dominical, that ensuing Year. Thus the odd Day shifts back the Dominical Letter every Year, by one Letter. And this Revolution would be terminated in 7 Years.

But secondly, There comes in another odd Day every 4th Year, being Leap-year. And in that Year there are consequently two such shifts ; the Sunday Letter being changed twice : Once at the beginning of the Year ; and the 2^d Time towards the latter End of *February*, by Interposition of the Bissextile, or Intercalar Day ; called Bissextile, because the 6th of the Calends of *March* is twice repeated. And the reason why this was done in that Month, and not rather at
the

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the End of the Year seems to be, because by *Numa's* Institution for the better regulating the Year, (in imitation of what the *Greeks* had done before) there had been an Intercalation of several Days, at that very Time in *February*.

To take a more easie Account of these Changes, there is appropriated a Cycle, which comprehends in order all the Variations of the Sunday Letter: and is therefore called, the Cycle of the Sun; composed of 4, which makes the Leap-year, and 7, the Change of the one odd Day, throughout the *Septimana*, or Week; 4 Times 7 gives 28. This Cycle begins at that Leap-year, wherein G and F are the Sunday Letters, and is terminated at 28. By the Table annexed, you may see how it proceeds. I have added to it the Cycle of the Moon, or golden Number; that you may view their Progress, from their being joined, and beginning together, in the Year, 1672.

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A. D.	Cyc. ☉	D. Letter	Cyc. ☾
1672	1	G.F	1
73	2	E	2
74	3	D	3
75	4	C	4
76	5	B.A	5
77	6	G	6
78	7	F	7
79	8	E	8
1680	9	D.C	9
81	10	B	10
82	11	A	11
83	12	G	12
84	13	F.E	13
85	14	D	14
86	15	C	15
87	16	B	16
88	17	A.G	17
89	18	F	18
1690	19	E	19
91	20	D	1
92	21	C.B	2
93	22	A	3
94	23	G	4
95	24	F	5
96	25	E.D	6
97	26	C	7
98	27	B	8
99	28	A	9
1700	1	G.F	10
701	2	E	11
702	3	D	12
703	4	C	13
704	5	B.A	14

Enc.

If

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It is likely the aforesaid Period was made by *Dionysius* (or whoever else first attempted it) in imitation of *Calippus*, who, many Ages before, in like manner, and for the like reason, joined four of *Meton's* Lunary *Decennoval* Cycles ; (what they are, you will see hereafter) out of which he made a Period of 76 Years, which had its beginning at the New-moon, next after the Summer Solstice, after the Victory of *Alexander* the Great over *Darius*.

And in the same manner, after the third Revolution of this Period, *Hipparchus* enlarged it, by adding together four of these *Calippic* Periods, and so obtain'd a great Period of 304 Years, containing 16 *Metonic* Cycles.

Upon the same Principle, but with a greater and nobler Design and Event, *Joseph Scaliger* formed a Period, which is become, as it were, a Standard to all others ; including and comprehending them all, and excells them all for Certainty : because we can, when we please, by Calculation of the Course of the Cycles of which it consists, trace up to the Head, or Beginning of it ;
and

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and so, infallibly determine in what Year of this Period, any given Year is to be placed; which by him was thus contrived.

Upon the *Dionysian* Period, formed, as I have shewn, out two Cycles, viz. of the Sun, and Moon, he grafted another most excellent one for Largeness and Certainty beyond all other; commencing 764 Years before the reputed *Epocha*, of the Creation in use with us, and serving for many thousand Years: And it was by joining the *Roman Indiction*, a Cycle of 15, to the other two Cycles, i. e. to the Period of *Dionysius*.

The *Indiction*, instituted by *Constantine*, the Great, is properly a Cycle of Tributes, orderly disposed for 15 Years: And by it Accounts of that kind were kept. Afterwards, in memory of the great Victory obtained by *Constantine* over *Maxentius*, 8. Cal. Octob. 312; by which an entire Freedom, and as it were, a new Life was given to Christianity. The Council of *Nice*, for the Honour of *Constantine*, ordain'd, that the Accounts of Years should be no longer kept by the Olympiads, which
till

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till that Time had been done; but that instead thereof, the *Indiction* should be made use of, by which to reckon and date their Years; which hath its *Epocha Anno Dom.* 313. Jan. 1.

Now this Cycle, as was said, was by *Scaliger* joined to the other two; making the *Epocha*, or Beginning, when all three Cycles begin together at 1, which comprehends a Period of 7980 Years; having its *Epoca* 764 Years before that of the Creation now in use: And this is stiled the *Julian* Period. The golden Number has its Period in 19 Years, the Cycle of the Sun in 28, the *Indiction* in 15: The two former, as before, multiplied one by the other, give 532; which multiplied by 15, gives 7980. This Period is of great use in Chronology, and they apply all other Periods and *Epocha's* to it.

Chronologers differ amongst themselves about most other great *Epocha's*; as particularly, that most principal *Epocha* of the Creation, which is accounted by Archbishop *Usher* to have been 4003 Years compleat before the vulgar *Æra* of *Christ*; by *Scaliger*, 3949; by *Peta-vius*, 3983; &c. So

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So that when I read of an Action said to be done in such a Year of the Creation, I am in uncertainty, whose Opinion amongst them my Author follows; and consequently know not what Year he means: But the *Julian Period* is so fixed by certain Calculation of the Revolution of those Cycles which make it, that it can lie under no Mistake or Doubt, but is an infallible Character of that one Year; to which therefore all other *Æra's* must be reduced, as well as we can.

It is necessary to know the different Periods, and *Epocha's* as they were in use amongst several Nations, and to know how to reduce them to our way of Accounting; else we cannot understand their Historians as to the true Date, and Time of Occurrences, which they relate and account after their own Way.

The *Greeks* accounted by the *Olympiads* chiefly, the *Romans* from the Building of *Rome*, and by their *Fasti Consulares*, as the *Athenians* did by their *Archontes*. The Astronomers from *Nabonnassar*. The *Æra* of *Dioclesian*, or of the *Coptites*, or *Martyrs*, in many places

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ces was used until the Christian *Æra* took place; and is still in use, as *Helvicius* relates, amongst *Arabian* and *Æthiopic* Christians. The *Arabians* and *Turks* account from the *Hegira*, or Flight of *Ma-homet*. The *Persians* from *Jezdagird*, &c.

I have, for this cause, in the following Tables, endeavoured to reduce the principal *Æra*'s, and Periods, to the Year of our Lord: Some having their *Epocha*'s before the Nativity, and some after.

<i>Scali-ger.</i>	<i>A. D.</i>	<i>I</i>	<i>1600</i>	<i>1569</i>	<i>1700</i>
	<i>Julian Period.</i>	4714	6313	6408	6413
	<i>Creation.</i>	3950	5549	5644	5649
	<i>Judaic Period.</i>	3761	5360	5455	5460
	<i>Deluge.</i>	2294	3893	3988	3993
	<i>Exodus Egypt</i>	1498	3097	3192	3197
	<i>Troy Desir.</i>	1183	2782	2877	2882
	<i>Solomon's Temple.</i>	1018	2617	2712	2717
	<i>Olympiad.</i>	1195	4594	3618	4619
	<i>Iphitus</i>	777	2376	2471	2476
	<i>V. C.</i>	753	2352	2447	2452
	<i>Nabonas-sar.</i>	749	2349	2444	2449
	<i>Julian Calendar.</i>	46	1645	1740	1745

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Heads of some Æra's after Christ	A. D.	Years expanded since, to the Year of our Lord.		
		1600	1695	1700
<i>Destruction of Jerusalem</i>	70	1530	1625	1630
<i>Dioclesian's Æra.</i>	284	1316	1411	1416
<i>Indiction.</i>	313	1287. 13	1382. 3	1387. 8
<i>Hegira.</i>	622	978	1073	1078
<i>Fezdagird.</i>	632	968	1063	1068
<i>Conquest.</i>	1066	534	629	634
<i>Calendar reformed.</i>	1582	18	113	118

As to these Tables, the Reader may observe, that Authors differ about fixing some of the principal Æra's (as I said before) especially that of the Creation; about which many Learned Men dissent from one another. But chiefly the Account of the *Septuagint*, and that likewise which a great part of the Eastern Churches do follow, and the Western did even after St. *Jerom's* Time; are very widely distant from that used by us at present, grounded (as 'tis thought) upon a different Reading of the Ancient Text of the *Hebrew* Bible, where it

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relates to the Lives of the Patriarchs, and some other Circumstances. And as the Number of Years are differently computed, so the Years themselves also have different Beginnings; some in Summer, and others in Winter, &c. and consequently, some about the Middle, compared with other Years: whence one half of such a Year seeming to belong to the preceeding, the other to the following Year of another *Æra*; the *Epocha* thereof is placed by some a Year sooner, by others a Year later. So that by reason of these, and other Confusions incident to Chronology, it is very difficult, I may say beyond humane Industry, to come to an exact and correct Determination; and therefore every one may, and will take leave to abound in his own sense.

C H A P. IV.

Of the Day as applied to measure the Year.

§ *Different Accounts of Years among the Ancients, and Confused.* § *The Julian Year.* § *Inequality of Natural Days; and Reasons thereof; With a short Table of Equation.*

HAVING no visibly distinct Periods, or Measures of our Time for all other Motions, but the Day, and Year, and Lunar-month; the Day is best known to us, being but of a short and easie Observation, and having so visible Change of Parts and easie to be measured by Mechanick Motions: But the Year is more obscure; though we are sensible of the Seasons, yet it is hard to find the Beginning and End of it. We are therefore constrained to make the Day serve to measure the Year as well as we can, though not commensurately to each Year (as has been shewed before) but by collecting the Fractions of Days in several Years, till they amount to an even Day; and then, by Addition or Sub-

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traction, reducing the Year as near as may be to his just Course.

I say, by Addition, or Subtraction of a Day; (when it is so collected) to or from the Account of the Days of the Year at certain Periods: As at every fourth Year to add the Bissextile-day, and at every Period of about 134 Years, to omit it; which is to subtract it: Not regarding the smaller Inequalities in the mean time all along, which will never exceed the Compass of a Day, before the Year be set right. For the reason of this Subtraction, see more afterwards.

This uneven Measure of the Year, by collection of Days, and the Measure not being then so perfectly known to the Ancients, rendered it very difficult for them to keep a just Account of Years, and to transmit a true Chronology to succeeding Ages.

Their civil Constitutions of the Year were after different manners in several Nations; some using the Sun's Year, but in divers Fashions; and some following the Moon, finding out *Embolism's*, or Equations, even to the Addition of whole

whole Months, to make all as even as they could.

But it may be thought, that whatever Methods the Ancients did apply in their Computations, and Settlements of the Spaces of Years ; yet they might probably have been kept in some Bounds of their Accounts, by the visible Characters of those Stated-measures, *viz.* Day, and Year ; and most especially of the Year.

For the Night and Day always made a natural Day of 24 Hours, in all Places remote from the uninhabitable Poles of the World ; and Winter and Summer always measured a Year : So that, if they observ'd but Winter and Summer, they could not lose a Year in their Accounts, though they were perhaps not able to measure the Year exactly by Days ; therefore it was as usual to them to express a large Space of Time, by so many Winters, or Harvests as by so many Years. I must not dissemble, that they who inhabit just under the Line, may seem to have two Winters, and two Summers : But there also they have four interchangeable Seasons,

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sions, which is enough whereby to measure the Year.

But at last *Julius Cæsar*, a Year before his Death, and 44, or 45 before *Christ*, with the help of *Sosigenes*, an *Ægyptian*, universally settled the Account of the Year; which we of *England* follow to this Day; and which from him is styled the *Julian Year*.

He supposed the Solar-year to contain just 365 Days, and a Quarter, or 6 Hours; and ordered the Continuance of the Account of Years, by adding a Day to every fourth Year, collected from the odd six Hours, remaining above 365 Days at the End of the Year; making three Years successively to consist of 365 Days, neglecting the odd 6 Hours; and the fourth Year (*Bissextile*, or Leap-year) of 366 Days; making thus (as he thought) a perpetual Equation of the yearly Account.

Having, before, taken notice of the Inequality of natural Days; I shall, before I pass farther, say somewhat more of it in this Place.

It is to be thought, that of himself, the Sun moves equally through the Degrees

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grees of the Ecliptic: But by reason of the Sun's Excentricity to the Earth, and Obliquity to the Equator; he appears to us to move unequally. The Sun passeth 360 Degrees of the Ecliptic, *i. e.* round it, in 365 Days, and almost a Quarter of a Day: So it is plain, that the Sun does not pass a whole Degree of the Ecliptic in a Day, one with another, but somewhat less, *viz.* 59'. 8': but he is found sometimes to exceed that Number, and sometimes to fall short of it.

So that 59' and 8" must be called his Middle, or mean Motion, being between his two Extrems, of sometimes going faster, and sometimes slower, which makes the Inequality of natural Days. About the Summer-solstice, being in his *Apogæum*, he is found, by Observation, to pass but 57 Minutes in a Day: And at the Winter-solstice, in his *Perigæum* 61', according to his apparent Motion.

The Consequence whereof is, That the natural Day of 24 Hours is shorter in Summer than in Winter: So that the Sun is 8 or 9 Days longer in passing the Northern half of the Ecliptic, than

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the Southern, Take but your Almanack in hand, and number the Days of the Sun's Passage between the Equinoctial Points, and you will find, that from the Sun's Entrance into *Aries* to his Entrance into *Libra*, are about 4 or 5 Hours above 186 Days; and from thence to his Entrance into *Aries*, are so much less than 179 Days; 7 or 8 Days difference. Which Entrances vary every Year, as influenced by the unequal Measures of the *Julian* Year, in respect of the Leap year, and the three following Years.

This, in general, might be supposed to be caused by the Sun's Excentricity to the Earth; but amongst Astronomers, there is a farther Account of Inequality of Days, and lately confirmed by Experience of our Watches, and Clocks; which has 4 Periods in a Year, and seems so irregular, that Excentricity alone cannot solve it, which else might answer the general Variations by Half-years: But this having four Periods in a Year, must have another joint Cause, which is the Obliquity of the Ecliptic to the Equator, and from thence, the Diurnal Diffe-

Differences of the Sun's *Right Ascensions*; which finish their Variations in each Quadrant of the Circle of the Ecliptic: and this being joined to the former Inequality, arising from Excentricity, makes the sequarterly, and seeming irregular Inequalities of natural Days. But yet these Differences are not so sensible to us, as to give any disturbance to our Account, and Use of natural Days; but rather affect the Measures of the Seasons of the Year.

This Inequality hath been diligently observed by several of our ingenious Clock makers, and Equations been made and used by them. But the most Authentic Tables of Equation of natural Days are handed to us by the Skill and Diligence of our Great Master in Astronomy, Mr. *Flamsteed*, and published in Mr. *Parker's* Almanacks for the Years 1692, and 1693. Out of which we may take a compendious View only of the Days of extream Inequality, and of the Mean between them; referring to the whole Table for a daily Account.

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Supposing a Watch, or a Clock, to be made and set so exactly to correspond with the Day of the Middle Motion of the Sun, that will continue to go truly according to that Motion of the Sun for a whole Year; the Sun's days sometimes lengthening, and sometimes shortning (I mean the natural Days) the Accounts of the Hours in the Sun-dial will vary from those of the Equal going Watch, according to the Table following.

Month.		Equation.		Watch.
<i>Jan.</i>	31	14'	49"	<i>Too Fast.</i>
<i>Apr.</i>	4	0.	0	
<i>May</i>	4	4.	13	<i>Too Slow.</i>
<i>Jun.</i>	6	0.	0	
<i>July</i>	15	5.	46	<i>Too Fast.</i>
<i>Aug.</i>	19	0.	0	
<i>Oct.</i>	22	16.	1	<i>Too Slow.</i>
<i>Dec.</i>	12	0.	0	
<i>Jan.</i>	31	14.	49	<i>Too Fast.</i>

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C-H A P. V.

The Deficiency of the Julian Year, and Calendar. § And from thence, Defects in our Ecclesiastical Computation; and how to Reform it.

BUT, to come nearer to our purpose, in reference to the Calendar. There is, in this long Tract of Time, a great Incongruity crept into our Calendar, by the Deficiency of the *Julian Year*, as we measure it.

The true Solar-year is computed to be constituted of 365 Days, 5^H Hours, 49' Minutes, and 16' second Minutes; so it falls short of the odd 6 Hours, by 10'. 44". The *Julian Year* is made to consist of 365 Days, six Hours, neglecting the odd Minutes; which neglect, in Tract of Time, has made a considerable Variation.

For the odd deficient Minutes (deficient, I mean, in the true Year, from the *Julian Year* of 365 Days and full 6 Hours) viz. 10'. 44". multiplied by 134, as being collected in so many Years, arise to 24 Hours, or a whole Day: And as many times 134 Years as are passed since *Julius Caesar's* Time, so many

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many Days will the true Account of the Sun's Motion, and the Seasons caused by it, vary, and fall sooner, than by the *Julian* Account.

We of *England* retain the *Julian* Constitution of the Year (as at first established throughout the *Roman* Empire) unreformed, without consideration of the said defective Minutes, and continue our Accounts by it, making our Dates *Stylo veteri*, as they who follow the *Gregorian* Reformation do *Stylo novo*. They have set their Calendar 10 Days forward, making our Tenth of *March* their Twentieth so that the Equinoctial-day, and all the other Accounts fall 10 Days sooner in our Calendar than in theirs; and will still in Tract of Time fall sooner, till it be reformed.

In *Cæsar's* Time, the true Vernal Equinox, or Sun's Entrance into *Aries*, was reputed to be about *March* 24th; which now by the aforesaid Defect of 10'. 44", is fallen back to about the 10th. of *March*.

The *Ecclesiastical* Computation of the Moveable Feasts regards the Time of the *Nicene* Council, *Anno* 325; at which,
Easter

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Easter day, on which the rest depend, was settled and fixed, to be always on the first Sunday after the first Full-moon after the *Vernal* Equinox.

The Equinox was then on *March* 21 ; and in regard that we are now guided, not by the true Equinox, but by the *Nicene* Rule, which supposed the Equinox to be always the 21 of *March*, and we still follow the same Rule : It hath caused a great *Anomaly*, or Irregularity in our Calendar, and wants to be reformed, and the Equinox to be rightly computed, as was designed in the *Gregorian* Reformation. And being once reformed and set right, it may be kept so (as to the Sun) without any considerable Variation, for many Ages ; by omitting one Leap-year, *i. e.* the Additional-day at the End of every 134 Years : As we add a Day every fourth Year to adjust the odd six Hours ; so to subtract a Day in 134 Years, to adjust the deficient Minutes.

As for other nicer Observations in the Course of the Sun, as the Variations of his *Excentricity*, of his *Apogæum*, of his *Declination*, &c. which have very long Periods ; Astronomers may be consulted

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ted by those that are Curious, since those Motions are not our Measures of Time.

Having therefore touched (so far as we are concerned) upon some *Phænomena* of the Motions of the Sun; we proceed now to those of the Moon.

C H A P. VI.

Of the Lunar Month, and Motion of the Moon; her Quarters, and Years. § Epaets explained. § The Golden Number. § Their Uses (with Tables) and particularly in relation to the first Column of the Calendar in the Common-prayer-book: Several Difficulties about it resolved. § Imperfections and Intricacies in these Accounts.

THE Moon has two Accounts of her Circuit, which are her Months, or as her Years of Revolution. One, her *Periodic Month*, or Month of *Pera-gration*, which chiefly respects her own proper Motion, or place in the Zodiac; by which she (like the Sun in his Year) performs her Revolution round the Zodiac,

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diac, from any one Point of it, to the same again. And this is made in 27^{D} , 74^{H} , $43'$.

The other is her *Synodic Month*, or Month of *Consecution*, and has relation to the Sun and Earth more particularly in respect of her *Phases*, or various Shapes, and of her Aspects to the Sun: and therefore this Month of hers is chiefly, or almost only, considered; in regard that the Sun is the chief Regulator of Time, and of the Moon's Appearances to our Sight.

This is her Circuit from one Conjunction with the Sun (which we call New-moon, Change, Prime,) to another Conjunction with the same; and because, when she passeth from her Conjunction, by what time she shall have accomplished her Month of Peragrations, in the same Space of Time, the Sun will be advanced almost a Sign of the Zodiac (which is 30 Degrees) viz. about 27 Degrees: Therefore she must overtake the Sun before she can be in Conjunction with him, which requires about two Days; the Sun also, in that Time, getting forwards about two Degrees more.

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This Month consists of 29 Days and a half, Middle-motion; in which her relation to the Sun and Earth is observed; *viz.* New-moon, or Conjunction; First-quarter, Full-moon, or Opposition; and Last-quarter; and all along her Age, *i. e.* Number of Days, from the last New-moon.

And this is most properly called Month (*Menſis*, from *Mén*, and Month, from Moon) the other Months, *viz.* the Days-month, of four Weeks, or 28 Days; and the Years-months, of the Sun's Passage through one of the 12 Signs, are called Months, only in Allusion to this Lunar-month; and have of themselves no perceptible or visible Periods, but are only gathered, by uniting a certain Number of Days, or taking a suitable Partition of the Year.

We have no visible Monition of the Returns of any other Periods, such as we have of the Day, by successive Light and Darkness; of the Year, by Succession of the four Seasons; and lastly, of this Month, by the Variations of the *Phases* of the Moon, and of her Quarters or Seasons, which make a visible

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visible Return, and may challenge the second Place, next to the Day, of signal Evidence to our Observation.

Now, as the Sun goes round his Circle (the Ecliptic) in 12 Months; so (that the Moon may keep better agreement with the Accounts of the Sun) we consider 12 of these Synodic Months, to make (as it were) a Year.

But this Year, or Twelve-month, by reason that the Moon's Months are shorter than those of the Sun, (her Month 29 $\frac{1}{2}$, the Sun's 30, and 31 Days) is about 11 Days shorter than the Sun's Year. The Sun's 365^D, 5^H, 49'; the Moon's 354^D, and about 8 Hours. Which Number of 11, being the Moon's Distance at the Year's-end before or beyond the Sun; is necessary to be observed and kept in mind for the whole following Year, and the collected Account of it for succeeding Years, by Addition of 11 to it every Year successively; if we will reduce the Moon's Accounts to those of the Sun's.

And this Number is called the *Epact*, viz. so many Days to be added, for an Equation of the Moon to the Sun, in respect of distance. E Sup-

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Supposing the Sun and Moon to be in Conjunction the first Day of the Year, at the End thereof the Moon's Twelve-month will be finished 11 Days sooner than that of the Sun: So, she will be then, at the End of the Sun's-year, 11 Days before him; and the next Year 11 Days more, *viz.* 22; &c.

The Circle of the Epact therefore begins the first Year at 11, the next Year add 11 to it, and it will be 22: the third Year add 11 more, which makes 33; cast out 30, being a whole Month (for the Moon cannot be above a whole Circle before or behind the Sun) and then the Epact is three. And thus proceed, till you shall have gone through all Variations of Epacts, and and begin again at 11; still casting away 30, or, 29, (for a whole Month) as often as it arrives to it, or exceeds it.

All these Variations are finished in 19 Years, nearly agreeing with the Course of the *Nodes*, *i. e.* the Points in the Ecliptic, where the Moon crosseth that Circle, as she passeth to her Northern or Southern Latitude; which *Nodes* are called

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called the Head, and Tail of the Dragon: The Head, when Northward; and the Tail, when towards the South of the Ecliptic. These continually vary, moving in *Antecedentia* about 3' per diem; which in 19 Years make 360 Degrees, or the whole Circle. So, their whole Change of Place, and Revolution round the Ecliptic, is finished in 19 Years, and then begins near the same Course again. For which METON, of old, in the Time of the *Peloponnesian* War, constituted a *Decennoval* Circle, or of 19 Years, the same which we now call the Golden-number; and was styled *Annus*, or *Periodus Metonis*.

The monthly Circuit of the Moon is (as that of the Sun) oblique to the Equator, and contrary to the daily Motion: But she moves also oblique to the Ecliptic. The Sun keeps constantly in the Ecliptic Circle, in the Middle of the Zodiac: But the Moon's Circuit is oblique also to the Ecliptic, crossing it twice in every Synodic Month; and proceeding to the Latitude of 5 Degrees Northward, and Southward. And if she happen to be in Conjunction with

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or Opposition to the Sun, when she is in either *Node*, crossing the Ecliptic; then there will be an Eclipse of the Sun, if in Conjunction; of the Moon; if in Opposition: whence it is called the Ecliptic Line or Circle. It hath been said, that the Moon changeth the *Nodes* or Place of her crossing, at the rate of 3 Minutes of a Degree, and somewhat more each Day: contrary to the Succession of the 12 Signs; so as to come round in 19 Years, and then begin again.

The Moon's monthly Course is not (to us) perfectly round, but in an Oval or Ecliptic Figure; sometimes nearer, and sometimes farther from the Earth. She is twice every Month in her *Apogæum*, and twice in her *Perigæum*: the *Apogæum*, near her Conjunction and Opposition; the *Perigæum*, near the two Quarters. Hence is caused an Inequality in her Motion.

The Cycle of 19 Years goes through all the Variations of the Epacts, as was said; and as it begins with 11, so after every Period of 19 Years, it begins at 11 again. And because the Moon,
in

in that Space, numbereth seven Months more than the Sun, by reason of her Deficiency of 11 Days in every Solar-year; seven Months are retrench'd in this whole *Decennovary* Progress of the Epacts, to reduce the Accounts of her Motion and Place to those of the Sun: *viz.* 30 (as that Number, or above it, accrues) is cast away six times; and 29 once, *viz.* between the last Year of one Cycle and the first of the next ensuing. As in 1690. The Cycle of the Epacts ended with 29: Add 11, it gives 40 for the Epact of the next Year, *viz.* 1691; from 40 you must cast away but 29, and then the Epact remaining is 11. But onwards, to the End of the Cycle, 30 is to be cast away as often as that Number ariseth, or a greater.

Thus the Cycle of *Epacts* serves at all times to shew the Habitude of the Moon to the Sun; *i. e.* her Distance from him.

But because the Epacts seem to lie in a confused Order of Numbers, making their Progression by 11 every Year, and so often casting out 30: therefore a Numeral Account set in Order against

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the Epacts, from 1, till it comes to 19; where each Number answers to, and designs its respective Epact, being applied to it, makes a perpetual Cycle of 19; which for its excellent Use. and because it was set in the Calendar in golden Letters, is called the *Golden Number*, or *Prime*.

Thus the first of the Epacts. 11, has 1, set against it; for the first of the Golden number; the next, *viz.* 22, has 2; the next 33 has 3; the fourth, *viz.* 14, has 4; &c. as in the first of the two Tables following.

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<i>Anno Dom.</i>	<i>Epaets</i>	<i>Golden Numb.</i>
1691	11	1
92	22	2
93	33	3
94	14	4
95	25	5
96	36	6
97	17	7
98	28	8
99	39	9
1700	20	10
1	31	11
2	12	12
3	23	13
4	34	14
5	15	15
6	26	16
7	37	17
8	18	18
9	29	19
1710	11	1
11	22	2
12	33	3
13	14	4
14	25	5
&c.	&c.	&c.

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<i>Ann. Dom.</i>	<i>Epacts</i>	<i>Golden Numb.</i>	<i>Month. July.</i>
1709	29	19	D. 1
1698	28	8	2
	27		+ 3
1706	26	16	4
1695	25	5	5
	24		+ 6
1703	23	13	7
1692	22	2	8
	21		+ 9
1700	20	10	10
	19		+ 11
1708	18	18	12
1697	17	7	13
	16		+ 14
1705	15	15	15
1694	14	4	16
	13		+ 17
1702	12	12	18
1691	11	1	19
	10		+ 20
1699	9	9	21
	8		22
1707	7	17	+ 23
1696	6	6	24
	5		+ 25
1704	4	14	26
1693	3	3	27
	2		+ 28
1701	1	11	29
			+ 30

1709

29

19

13

So

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So that, as the Epact is (*i. e.* the Number of Days, by which the End of the Moon's 12 Months, at the End of the Solar-year is found to fall short of the Sun's New-year:) So is the Course of the Moon, or her Distance from the Sun, accounted for the whole ensuing Year, and for every nineteenth Year after for ever, as was supposed.

And the Golden-number is the *Index*, or *Character* of the Epacts, in a perpetual Cycle; to find which of those 19 Years, the present, or any given Year is: and consequently, what is then the Epact; and so shews for ever the yearly Course of the Moon in relation to the Sun.

The Golden-number being the *Index*, and Cycle of Epacts, the principal Use of it is, to find the Epacts; and so they both serve indifferently for the Accounts of the Moon, and furnish you with many useful Rules and Tables for several Purposes. As by the Golden-number, and Dominical-letter given, to find *Easter-day* for ever. Such a Table you have before the Book of Common-Prayer. By the Epact, and Day of the Month, is found the Distance at any time,

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time, how many days the Moon is from the Sun. It is thus applied to find the Moon's Age ; *i. e.* how many Days are past since the last Conjunction ; which shews withal how near she is to her Quarters, Full, or next New-moon ; and is useful to find her coming to the South, and consequently the Tides, &c.

The Moon's Age is thus found, for any given Day of any Month. Add to the Epact the Day of the Month, and the *Ordinal* Number of that Month from *March* inclusive, (because the Epact begins at *March*) and the Summ of these (casting away 30, or 29, as often as it ariseth) is the Age of the Moon, *ex. gr.* *Febr. 2. 169¹₂* to find the Moon's Age, say thus ; Epact 11, Day of Month 2, Month from *March* 12 ; Summ of these 25 : The Moon is then 25 Days old. Again, if it be sought *March 25, 1692.* Epact 22, Day of Month 25, Month 1 ; in all 48 ; cast away 30, and 18 is the Moon's Age.

The reason why you are so to reckon the Months (from *March*) by Addition of an Unit, every succeeding Month, is ; because the Moon's-year of twelve Months, being 11 Days shorter than
that

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that of the Sun ; it is in effect a Day for every Month, which is thus accounted for.

You see then, the chief Use of the Epacts is (as well as we can) to reconcile the twelve Months of the Moon to the Sun's year, or Twelve-month ; and to measure every single Lunar-month all along, by the Days of the Solar month ; *i. e.* to make any Day of any Solar month so to correspond, by help of the Epacts, as to shew the present Day of the Month of the Moon, which Day according to the Number of it, is called the Age of the Moon, which might have succeeded a little better, if it had pleased the Institutors of the civil Months of the Sun, to have ordered and placed them alternately odd and even ; of 31 and 30 Days, beginning (suppose) at *March*, and ending at *February* : And *February* in common Years to have 29 Days, and in the Leap-year, 30. But since the old way obtains by Prescription we must follow it, though with some Inconvenience.

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The foregoing Rule, to find the Age of the Moon at all Times, on any Day of any Solar-month, cannot shew precisely an exact Account of the Moon, because of the Inequality of the Motions of the Sun, and of the Moon, and of the Number of Days of the Solar-months; though the last of these is somewhat helped by observing the old Rule, *Impar Luna pari, Par fiat in Impare Mense*; i.e. by casting out, for a whole Month of the Moon (when there is occasion) 29. in Solar-months of 30 Days; and 30, when the Month consists of 31 Days. I say, though the aforesaid Rule is not exact, yet it comes so near, that it is very fit and necessary for common Use; being always at hand or in memory.

If the Lunations be observed, and set down for a whole Course of the Golden-number, or Cycle of 19 Years, which is the Cycle of the Moon; the same Observations will serve, and be verified, through the next Cycle of 19 Years, in the same Order; and so on for succeeding Cycles, (as hath been supposed) for ever.

And

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And therefore the Golden number, in the first Column of the Calendar, before the Book of Common-Prayer, is, as a Rule for ever, set before the Day of each Month, in which the Change or Conjunction of the Moon shall happen; whensoever such is the Golden-number, as is there set down. As, if you look, *ex. gr.* upon the Month of *July*, you will see 19 before or against the first Day, 8 before the second, 16 before the fourth, 5 before the fifth, &c. That is, whensoever the Golden-number is 19, there will be New-moon on the first Day of *July*; when 8, on the second; if 16, on the fourth; if 5, then the fifth Day, &c.

And though in the aforesaid Column, the Numbers which denote the Golden number, seem to stand confusedly, without any Order; 19, 8, (and after a Space between) 16, 5; yet they precisely follow the progressive Order of the Epacts, of which they are but *Indices*; beginning at the greatest Epact, *viz.* 29, and so descending in order till they come to the least, *viz.* 1; as you may see in the two middle Columns

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lumns of the second Table preceeding; where the Golden-numbers, 19, 8, 16, 5, 13, 2, 10, &c. are *Indices* of the Epacts in order, viz. 29, 28, 26, 25, 23, 22, 20, &c.

And the reason why they fall in that order in the Calendar, from the greatest Epacts progressively to the least, is; because the greatest Epacts denote a greater Distance of the Moon before the Sun, and consequently a nearer approach to her Conjunction. Therefore the *Indices* of these Epacts are set earlier in the Calendar of the Sun's Month, to keep some accord, (as the Sun's longer and uneven Months will permit) between the Moon's Month, and that of the Sun. And, for the same reason, as the Epacts decrease, so they fall later in the Calendar-month. If you find one, or two, or more of the less *Epacts* set in the beginning; and one, or two, or more greater at the End of the Calendar-month: it happens through the Inequality of the Moon's and Sun's Months.

It is here needful to be better explained, how the Moon is said to be *Behind*,
and

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and how *Before*, the Sun, both which, or either of them, it may be understood to be.

The Moon goes round her Circuit above 12 Times, whilst the Sun passeth once about his; And so many Times *overtakes*; and also goes *beyond* the Sun. In every Time, to keep her Habitude to the Sun, she goes more than a Round, having the whole Zodiac, and about one of the 12 Signs more, to pass after her Conjunction, before she overtakes the Sun again. And if she may be said to *overtake* the Sun; she may not improperly be said to be *behind* him, until she overtake him. If we look back upon the last pass'd Conjunction; Then the Moon was joined with the Sun, and moving swifter, is now got *before* him: If upon the next approaching Conjunction: Then the Moon is drawing towards him, and is *behind* him.

Thus, when the Epact is 1; the Moon, at the End of the Year, will be 11 Days in her Progress, beyond or before the Sun, having got so far since the last Conjunction: But in respect of the next ensuing Conjunction, to
which

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which her Motion tends, she will be found about 19 Days *behind* the Sun. Thus she is both *before*, and *behind* the Sun, 12 (or in some Years 13) Times in a Year.

But since the *Epaet* is properly the Number of Days, by which the Moon has finished her 12 Months sooner than the Sun his; or, (which amounts to the same) the Number of Days of the Age of the Moon, *viz.* which have passed between her last Conjunction, and the Close of the Sun's year, though in the Remainder or Complement of Days which respect her next ensuing Conjunction, she be *behind* the Sun: yet, in the former Respect, she must be said to be *before* him. And therefore it may be less exceptionable to consider her as *before* the Sun, and correct those Passages which seem to look otherwise.

To explain this more clearly; If two run a Race, he that comes first to the Post, is properly said to be *before* the other: So the Moon beginning her 12 Months with the Sun, and arriving at the End of them 11 Days before the Sun, is properly said to be so much
before

before him. And consequently (both of them continuing their Course of Revolutions) she keeps on, throughout the whole ensuing Year, 11 Days before the Sun in her *Synodic* Chase, besides her gaining moreover, about a Day in every Solar-month; *i. e.* 11 Days in 12 Solar-months. Therefore, as was said, *p.* 82. to accommodate the Course of the Month of the Day-moon to that of the Sun, we add all along to the Day of the Solar-month, the Number of those Days in the foregoing Year, between the latest Conjunction of the Moon, and the End of the Sun's year, which are therefore called *Epaets*, together with the Number of Months from *March*.

We might more properly reckon by the Day of the Moon's-month, as we do by that of the Sun; but then *The Day of the Month* would be an ambiguous Term, relating as well to the Moon, as to the Sun. Therefore it is usually termed *The Age of the Moon*, which is the same with *The Day of her Month*, but wholly avoids the Ambiguity.

Now the *Epaets* varying every Year by Progression of 11; It is so, that the

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Greater the *Epaet*, (*i.e.* the Age of the Moon at the End of the Sun's-year,) happens to be ; so much shorter will be the Remainder, or Complement of Days to the next Conjunction : which shews the Reason of the Order of *Epaets*, pointed at by the Golden-number, in the first Column of the Church-Calendar.

I take the Month of *July* there, in which to make Instance, because it begins with the greatest *Epaet* 29, pointed at by the Golden-number 19 : The Reader will find those Columns in the said Calendar very carelessly Printed ; but they may be easily corrected by the Table foregoing, observing the Order of those Numbers.

When the *Epaet* is 29, and Golden-number 19, as it was 1690, and also 1709 : The true Complement to the next New-moon was but half a Day. So the Moon was in her Change (not truly, but according to that Rule by the Golden-number) the first of *July* ; and that was the first Day both of the Sun's, and of the Moon's month, and you may reckon the Age of the Moon, by the Day of the Month, throughout that

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that one Lunation. Otherwise the Moon's Age must be reconciled to the Day of the Month, by the Epacts, and Number of Months from *March*. The Solar-month being made the Standard, to which other Measures are reduced.

When the Moon changed (according to the same Account) on the second Day of *July*, as *Anno Dom.* 1698, the Epact was 28. Golden-number 8, and the Second of *July* was the First of the Moon. When on the Fourth of *July*, as *Anno Domini* 1687, 1706. Then the Epact was 26, and Golden-number 16 ; and the Fourth of *July*, the First of the Moon. And thus still the Epacts decrease in order, as the Days of the Month go forward. Now this shews plainly the Reason of the Regular progressive Order (by Decrease) of the Epacts; and of the seeming Disorder of the Golden-number in that Calendar, throughout the Month of *July*: And in the same manner in all other Months: always allowing for the Differences in the Places of those Numbers. which will arise from the Inequality of the Solar and Lunar-months. From whence it is,

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That in the Year 1709, *Epaēt* 29, the Moon's Change was allotted to *Apr.* 4. *May* 3. *June* 2. *July* 1, and 31. *Aug.* 29. *Septemb.* 27, &c.

If you ask, Why there are void Spaces in that first Column of the Calendar, some Days of the Month having no Golden-numbers set against them? You must remember and consider that there are no more Varieties of *Epaēts* than 19, so measured by the Golden-number, and they arise out of their Annual Progression by 11, till you go through all Variations, and begin again at 11; which is done in 19 Progressions, or 19 Years, as you may see in the first Table.

So that they are but enough to set against 19 Days of 29, or 30 in the Calendar; and 10 of the Days having no *Epaēt*, can have no Golden-number against them, and sometimes an Eleventh-day, *viz.* the Space between the End of one Cycle, and beginning of another.

Take an instance of the Month of *July*, in the second Table; the Days whereof are set laterally after and against the Columns of Golden-number, and of *Epaēts*, and of the correspondent

dent Years of our Lord, within one Cycle.

Now, there are no *Epact's* in the aforesaid Progression by 11, which happen to fall on any of these ten Numbers following; viz. 27, 24, 21, 19, 16, 13, 10, 8, 5, 2. So that those Days of that Month, where those Numbers should in order fall, because they have no *Epact*, can have no Golden-number set before them: and therefore that Space is left void, viz. as to this Month of *July*, the 3^d, 6, 9, 11, 14, 17, 20, 22, 25, 28th Days, (and 30th of the next Cycle.) By which you may plainly see the Reason of those void Spaces in this, or any other Month, of the Ecclesiastical Calendar.

It was said before, that the Rule to find the Moon's Age, is not *Precise*: and the Reason is, partly because of the Inequality of her Motion, sometimes swifter, sometimes slower: and partly because of the Sun's unequal Motion; and partly because of the odd Measure of the Solar-year, spoken of before. So that I may say, No General Rule, in these Cases, without Limitations, and Equations, can be exact. I will insist

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only on the last Incumbrance; *viz.* the odd Measure of the Solar-year; I mean the odd, or supernumerary, 6 Hours; which are not accounted in the three Years after the Leap-year, which (as I said) consists of no more than 365 Days, without the odd six Hours.

Suppose you apply this Rule to find the Moon's Age, and suppose it exactly true (which indeed it is not) for any Day, or Month, in a Year, that is, the first Year after *Bissextile*; you will find it not agree exactly to the succeeding three Years. For the second Year after *Bissextile*, takes his beginning six Hours before the End of the foregoing Year be fulfilled: Therefore the Computations of the Motions and Places of the Sun and Moon will be six Hours earlier all that Year, than they will be pointed at by the Rule: And for the same reason, in the next Year, *viz.* the third after Leap-year, the Sun and Moon's Places will be computed twelve Hours sooner; and in the Leap-year, for the former two Months, *viz.* till after the *Intercalar* Day, 18 Hours sooner; and in the Remainder of that Year, six Hours later.

You

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You see how considerable it is, in which of these four Years, you make use of Rules, or Tables, for the Heavenly Motions; because there may be near 6, or 12, or 18 Hours difference in the true Age of the Moon, from the time assigned by the Rule. And the like happens to the Computation of the Sun's Entrance into the four Cardinal Signs, and of his whole yearly Progress in the Leap-year, and the three Years after it respectively; and so likewise of the other Planets.

C H A P. VII.

An important Defect in Ecclesiastical Computations by the Nicene Rule, arising from hence; that the Golden Number does not exactly measure the Moon's Cycle. § The Sun's Account above ten Days too late, and the Moon's above four; and needs Rectification.

BUT besides these Astronomical Intricacies of Calculation, which I have transiently mentioned; there re-

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mains one most considerable, important Defect, in Ecclesiastical Computations after the *Nicene* Rule, in relation to the Moon.

For the Golden-number does not so exactly comply with and measure the Moon's Cycle, but that there is found an *Anomaly*, (like that of the Sun's *Anticipations* of 10'. 44".) For though the Moon in 19 Years seems to renew her same Course respective to the Sun, yet it is found, she falls short in that time almost an Hour and half, which in 16 *Decennoval* Cycles amount to 24 Hours, or a Natural-day; viz. 16 Hours, and 16 half Hours: And thus 16 Cycles are compleated in 304 Years, or rather, as some more accurately seem to calculate, in 312 Years, making the *Anticipation* of the Moon, at the End of every Cycle, to be somewhat less, viz. 1^H, 27', 32", 42".

Now as the *Nicene* Council fixed the Equinox upon the 21 of *March*, for the finding out of *Easter*, which has caused the Misguidance from the Sun, which we lie under, in respect of *Easter*, and the moveable Feasts; so the
same

same Council likewise fixed the Accounts of the Moon, upon the Cycle of the Golden-number, as it then pointed out the Lunations, and therefore placed it in the Calendar, for a perpetual Rule (as is said before.)

But now we find (for the reasons before assigned) that the Golden-number, so fixed, gives us the New-moon's, and Full, and other Accounts of the Moon, more than four Days too late; by reason of the aforesaid *Anticipation* and our neglect of it: which also wants Reformation, like that which is attempted in the *Gregorian* Calendar.

For, at this time, the Sun's Account, by our old *Julian* Year, is above ten Days too late: and that of the Moon above four Days. When therefore the Accounts of the Moon are also rectified and reformed, and the Golden-numbers once rightly applied to the Days of the Months; they may be kept so for many Ages, and kept right; by abridging one Day at every End of 312 Years, for an Equation of the Moon's Cycle.

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The Council of *Nice* was celebrated *Anno Domini* 325 ; since which there have passed four times 312 Years, to the Year 1573 : which then caused an Error of four Days, and was reformed soon after, *viz.* 1582. From thence, *viz.* 1573. to the Year 1693, there have passed 120 Years ; which contain six Cycles of the Moon, and six Years currant, which cause a farther *Anticipation* of almost nine Hours. So much the Rule, by the Golden number, assigns the *Aspects* of the Moon to the Sun later, than by true Account they are found to be.

Therefore, in the aforesaid first Column, in the Calendar before our Book of Common-prayer in any of the Months, having found out, amongst those Figures of that Column, the Golden-number for the present Year ; instead of the Day of the Month over-against it, reckon four Days and nine Hours before it, and you have the Day of the Moon for common Use : or, which amounts to the same, reckon that Day of the Month which has the Golden-number belonging

ing to it (over-against it) for the fifth Day of the Moon's Age.

Thus much hath been said of the Accounts of the Sun and Moon, principally for the better Understanding of our Calendar ; which being constituted after the old *Julian* Year, we may see what need there is of rectifying it from those *Anomalies*, which in this long Tract of Time, since the *Nicene* Council, have crept into it ; tending to the displacing of the Seasons of the Year, and misplacing the Festivals of the Church : And to shew also the Grounds and Reasons of the Cycle of the Moon's *Epacts*, viz. the Golden-number ; which so often occurs to us, and of which we may make so frequent and continual Use.

C H A P. VIII.

Conclusion ; containing some short Observations, and Practical Deductions. § With a brief Account of the Author's New Hypothesis, concerning the Natural Production and Differences of the Letters of the Alphabet ; relating to a Treatise formerly Published by him, Of the Elements of Speech : Of which the Contents also are annexed.

FROM what hath been said, the Reader may (amongst other things) observe the Agreements, and Differences of the Measures of Time, to, and from those other Material Permanent Measures of Distance, and Capacity, and Weight, first spoken of.

And that, of the Measures of Time, some are Natural and Universal ; and some Arbitrary and Artificial, and confined diversly to several Nations.

The *Noctidial* Day, the Lunar *Periodic* Month, and the Solar-year are Natural and Universal ; but Incommensurate

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surate each to other, and difficult to be reconciled: Yet we are constrained to make use of them, as Measures to one another, reducing the Disagreements; by observing, and collecting, and allowing for their Differences.

Other Measures, as Hour, Week, Month of Weeks. Solar Calendar Months, are more Artificial and Arbitrary, for the Use of common Life; and serve for Measures, by Publick Sanction, Consent, and Usage of so many Nations as are agreed to them, and so are made very useful, by which to measure the other: The former also, though Natural and Universal, yet are subject to the like Regulations.

If we measure the Year by Days, there will be found a Remainder at last of about six Hours above 365 Days; Whence *Julius Cæsar* ordained, that in the Account of Years, the odd six Hours should be omitted in the First, and a Second, and a Third Year, and collected every Fourth Year; adding the *Bissex-tile*-day to that Year. So you see we follow a Calendar not exactly true in Nature, nor Equal, but Artificially contrived

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ttived for common Use, by the *Julian* Institution.

And the Calendar months are likewise Arbitrarily, and Unequally settled by the same Power ; by which Months we to this Day account, and they measure and make up that which we call the *Julian* Year.

Now take a short Review of some Measures relating to the Calendar, which have been more largely treated in the foregoing Discourse.

Measure the Year by Days ; and the Remaining odd Part of a Day, which *κατὰ πλάτῳ*, or *Numero rotundo*, is accounted six Hours, shews the Reason of the *Bissextile*, or Leap year.

Again, Measure the Year by Weeks ; and the Remaining odd Day, for three Years successively, and two odd Days in the Fourth, or Leap year, shew the Reason of the yearly Change of the *Dominical Letter*, and the Nature and Use of the Cycle of the Sun, which is 28.

Again, Measure the Year by Lunar *Synodic* Months ; and the Remaining eleven Days, by which twelve Lunar-months fall short of the Solar-year, make the
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the *Epaëts*, and shew the Reason of the Observation and Use.

Again, Pursue and Observe all the Variations of *Epaëts*, till they return to the same again; and you will find that Revolution to be made at the End of every nineteenth Year: which Number of Nineteen constitutes the Cycle of the Moon, *viz.* the *Golden Number*. And thus proceeds our *Julian Year*.

But then, Consider more narrowly, that the odd Hours at the End of the Solar-year, are not indeed fully six, but are deficient 10', 44"; which Deficiency in 134 Years (collected) amounts to a whole Day. And hence may be seen the Reason, why the *Vernal Equinox*, which at the Time of the *Nicene Council* fell upon the 21th of *March*, falls now above 11 Days sooner; *viz.* about the 9th of *March*: which was one Reason of the *Gregorian Reformation* of the Calendar.

Again, consider, that the Golden-number does not perfectly correspond with so many Revolutions of the Moon, as are made in that Time; but the Period of those Revolutions is accomplished

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in somewhat less Space than full 19 Years; *viz.* near an Hour and half sooner: which sets her back so much in every Cycle; and collected, amounts to a whole Day in about 312 Years; which is called the *degeneration*, or *Anticipation* of the Moon. So that, following the Accounts of the Moon; as directed by that perpetual Cycle of the Moon, called the Golden-number, placed for that purpose at the *Nicene* Council, before, and along the Ecclesiastic Calendar, and continued still in ours, we now find above four Days difference; *viz.* so much later than the true Account, which was another Reason of the Reformation of the Calendar.

Remember lastly, what has been observed before, (to shew the Power of *Legislative* Authority, and Consent, and Practice, in ordering and using Measures,) That the Measure of the Year by Solar-months, as constituted by *Julius Caesar*, and a little altered by *Augustus* his Successor; tho' it be Irregular, Imperfect, Unequal, and wholly Artificial, having little Agreement with the natural Measures of Time: Yet because
it

it is made to consist of *Integer* Days, and consequently more easie and certain to be applied; viz. Days to Months, and Months to Years: is become, by the help of Authentick Calendars, one of the principal Measures of Time for common Use; especially when joined with the other.

We measure the Beginning, and Progress, and End of the Year, by these Months, and the Days of which they consist; we Date all Affairs, Actions, and Accidents of humane Life, and reflect back upon them, by the help of this certain Character of Time, when joined with other Measures: as, Such a Day of such a Month, of such a Year in some certain Period or *Epocha*. *Ex. gr.* King CHARLES the Second was Crowned on the 23^d Day of the Month of *April*, in the Year of our Vulgar Christian *Æra* 1661; and the Time elapsed to this, is so many Years, Months, and Days; as may be found by computing. Likewise for Time to come; There will be an Eclipse of the Moon, the 27th Day of *June*, 1694.

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These are easie and useful known Characters of Time, deduced from those Measures settled by Authority, and Use: And in all Ages, where they did not all compute by Weeks, yet still the Year was measured by Months, though sometimes by Solar, and sometimes by Lunar-months; and differently ordered, as it pleased the Authors of those Constitutions.

And, if the Reader, by all that has been said, find the Satisfaction of seeing plainly the Reasons, and Nature, and Use of the Measures for Time; and of the Constitutions and Alterations, and Reformations of those Measures it is what the Author designed.

To that End, this Discourse has been carried on with all possible plainness, suitable to those, for whose sake it is made publick: the Author not pretending, nor owning Ability to perform great Matters in this kind, or any other, or to make new Discoveries. Though on another Subject, concerning the *Letters* of the *Alphabet*, more accurately considered by him, for a further End than a bare *Philosophical* Contemplation of the *Alphabet*;

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viz. The Application of it to a dumb Person, then with him in his House ; which obliged, and urged him to more Sedulity in bending his Thoughts upon it, such as are since published, *Anno* 1669. in a *Treatise Of the Elements of Speech*: He thinks he may, without Vanity, because not without sufficient Provocation, commend, and submit to the Reader's impartial Judgment, a certain new *Hypothesis* of the natural Production, and Differences of the *Letters* of the *Alphabet*: Reducing all different *Articulations* of *Consonants* (to instance in them) made by the *Organs* of Speech, to the Number of Nine, and supplying the Essential Differences of the remaining Number of those *Letters*, by finding out four sufficient Discriminations of *Letters*, from their *Material* Part, *i. e.* *Sound*, which is *Articulated* ; there being four Differences of *Sound* which go to the making of *Letters*: *viz.* *Breath Oral*, (as in Whispering) *Voice Oral*, *Breath Ore-Nasal*, and *Voice Ore-Nasal*. Thus P. B. M. and a *Spiritual* M, (which is not in use) are distinguished by those Differences of *Sound*,

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though they all have the same, and but one *Articulation* by the *Organs* of Speech. Like as we may, with one *Seal* impressed upon Wax of four several Colours, (suppose Yellow, and Green, and Red, and Black) make four as different *Signs*, as from four different *Seals* upon the same coloured Wax.

Thus, Every single *Articulation*, impressed upon those four distinct *Matters* of *Sound*, produceth four distinct *Consonant Letters*, which ought to be ranged in every single *Classis* of *Articulation*. Thus to one and the same *Articulation* by the Lips, belong B, P, M, M, and differ only in *Sound*, as hath been said. Now nine *Articulations* impressed upon four sorts of different *Matter* of *Sound*, make in all thirty six *Consonants*, wherein are comprised all possible *Consonants* used by any Nation in the World: And they do orderly, and equally fill up the *Abacus*, and *Classes* of *Consonants*. Like as nine distinct *Seals*, impressed upon four Sorts of Wax, viz. of four several Colours, may serve to make thirty six sensible Discriminations for *Signs* to be agreed upon for mutual Communication.

cation. For, the Impression of a Lyon upon Black-wax will differ from that which is made upon Red, as sensibly as a Lyon differs from a Boar on the same coloured Wax. We may impute the *Formal* Differences to the nine *Seals* which give the Impression and the Differences *Material*, to the four Sorts of Wax which receive them: resembling the 9 *Articulations* in Speech, giving *Form*; and four Sorts of *Sound*, being the *Material* Part, which receives the Impressions of the *Articulating* Motions.

Whereas other Writers on this Subject, taking for granted, the Number of *Articulations* to be equal to the Number of *Letters*, each *Letter* having a peculiar distinct *Articulation*; in their Table, or *Abacus* of *Letters*, rank some of those *Letters* in *Ternaries*, some in *Pairs*, and let some stand single; not giving any Reason for the void Spaces in the *Abacus*, nor for the Order in which they are placed: Except, as to the latter, by referring to the Parts of the Month, where the *Articulations* are formed; beginning, *ex. gr.* at the *Labial Letters*,

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of which they find three, and suppose them to be framed by three several *Articulations* by the Lips; whereas there is indeed but one *Articulation*, which differenceth the *Labial Letters* from those made by other *Organs*; but between themselves, these three are differenced by the *Matter of Sound Articulated*.

Then, rejecting, and laying aside such *Letters* of those thirty six, as are not graceful, nor easie to be pronounced, having enough besides: Seventeen *Consonants* are cast off, for reasons there assigned, and marked in the *Abacus* with an *Obelisk*; and 19 are retained for the Use of Speech. And it is no wonder, if they who considered but 19, or about that Number, could not tell how to rank them in *Equal Classes*; whereas, in the *Author's Abacus*, or Table of *Letters*, the whole Number of *Consonants*, viz. 36. will be found equally ranged, with their proper Differences, and Productions: 19 of them being owned for the Use of Speech, and the remaining 17 noted with a Mark of Rejection. For which the Reader is referred to the aforesaid *Treatise*.

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Which *Treatise* lying not so plain for want of an *Index* ; here is annexed a short View of the *Contents* of it.

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